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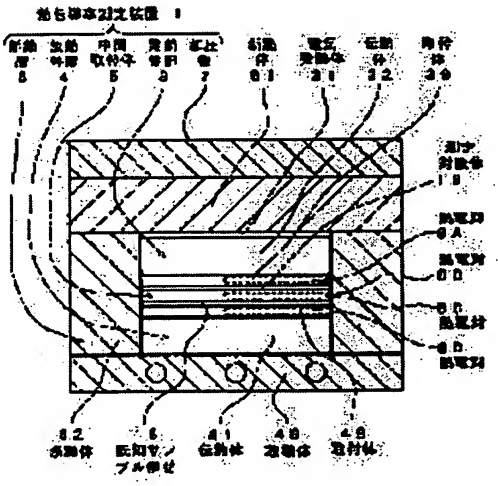
(54) THERMAL CONDUCTIVITY MEASURING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a thermal conductivity measuring device capable of obtaining highly precisely the thermal conductivity value of a plate member in which a filler or the like is used.

SOLUTION: This thermal conductivity measuring device 1 is equipped with an electric heating element 31, a heat transfer body 32 for a heating element part, the heating element part 3 having a mounting body 39 for a thermocouple 8A, a heat transfer body 41 for a radiator part, a mounting body 49 for a thermocouple 8D, the radiator part 4 having a water- cooling radiator 43, an intermediate mounting body 5 for thermocouples 8B, 8C, an adiabatic layer 6 having a heat insulating body 61 for covering the upper part of the electric heating element 31 and a heat insulator 62 for covering the side faces of the heating element part 3, the heat transfer body 41 or the like, and a presser plate 7 arranged on the upper surface of the heat insulating body 61. With this formation, a measuring object 19 whose thermal conductivity is required to be obtained is inserted between the mounting body 39 and the intermediate mounting body 5, and a known sample member 18 having a known thermal conductivity is inserted between the intermediate mounting body 5 and the mounting body 49, and the thermal conductivity of the measuring object 19 is obtained by using the thermal conductivity of the known sample member 18 and the ratio of the output difference between the



thermocouples 8A, 8B with respect to the output difference between the thermocouples 8C, 8D.

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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The heating element section which has the heat transfer object for the heating element sections made from thermally conductive material with which the temperature detecting element for heating element section sides was arranged in the plane end-face side while giving an electric heating element and the heat which has a plane end face and was generated with the electric heating element to a measuring object object from said plane end face, While receiving the heat generated with the radiator and said electric heating element by the plane end face which has the almost same field configuration and dimension as the plane end face of the heat transfer object for the heating element sections through a measuring object object and transporting to said radiator The radiator section which has a heat transfer object with the temperature detecting element for the radiator section sides which were made to counter mostly the temperature detecting element for heating element section sides, and were arranged in the plane end-face side for the radiator sections made from thermally conductive material, It has the thermal break arranged around the heat transfer object for the radiator sections, a measuring object object, and the heating element section. Between each plane end face of the heating element section and the radiator section Thermal conductivity measuring apparatus characterized by inserting said measuring object object with the field configuration and the dimension almost same plate-like as the plane end face of the heat transfer object for the heating element sections, and being stuck to each of the flat surface of the both sides of this measuring object object by said plane end face of the heating element section and the radiator section.
[Claim 2] In thermal conductivity measuring apparatus according to claim 1 Said heating element section and/or said radiator section are thermal conductivity measuring apparatus which has an attachment object for the temperature detecting elements for attaching the temperature detecting element for heating element section sides, and the temperature detecting element for radiator section sides in a measuring object object side, and is characterized by this attachment object having the almost same field configuration and dimension as the plane end face by the side of the measuring object object of the heat transfer object for the heating element sections by the product made from thermally conductive material.

[Claim 3] It is the thermal conductivity measuring apparatus which the exoergic section is distributed over the range of a field configuration and a dimension with said electric heating element almost equivalent to the plane end face of the heat transfer object for the heating element sections, is arranged in thermal conductivity measuring apparatus according to claim 1 or 2, and is characterized by forming said heat transfer object for the heating element sections in the plane in which the end face which an electric heating element touches has the almost same field configuration and dimension as said plane end face by the side of a measuring object object.
[Claim 4] In thermal conductivity measuring apparatus given in either to claims 1-3 Between said heating element sections and measuring object objects or between a measuring object object and said radiator section It has the known sample member by which the middle attachment object and thermal conductivity for temperature detecting elements by which the temperature detecting element was

arranged in the part which counters mostly the temperature detecting element for the heating element sections were produced with the known ingredient. A known sample member is formed in plate-like [of the almost same field configuration and dimension as a measuring object object]. A middle attachment object is thermal conductivity measuring apparatus characterized by being arranged in contact with a measuring object object while being formed in plate-like [with the almost same field configuration and dimension as the plane end face by the side of the measuring object object of said heat transfer object for the heating element sections].

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] With respect to the thermal conductivity measuring apparatus which measures the thermal conductivity of a plate-like measuring object object, this invention relates to that configuration that enables highly precise measurement of thermal conductivity, even if local thermal conductivity values, such as FRP material, are uneven measuring object objects in the direction of a field.
[0002]
[Description of the Prior Art] Although many kinds, such as an electric insulation film, of plate-like electric insulators are used for the electric insulation of an electric machine, in order to ask for the thermal conductivity of plate-like members, such as this, the thermal conductivity measuring apparatus for plate-like members is used. Then, the equipment indicated by JP,53-107382,A as equipment which can ask for the thermal conductivity of a plate-like member with the very thin thickness below 0.1 [mm] is known. This official report explains the thermal conductivity measuring apparatus for the plate-like members of the conventional example using drawing 8 based on the contents of well-known equipment below. Drawing 8 is drawing of longitudinal section showing the important section of the thermal conductivity measuring apparatus for the plate-like members of the conventional example with a measuring object object here. In addition, it is shown as a condition which developed the member and measuring object object which constitute thermal conductivity measuring apparatus from drawing 8 .
[0003] In drawing 8 , 9 is the thermal conductivity measuring apparatus for the plate-like members of the conventional example equipped with the measurement implement 91 which has the thermal break 94 the electric heating element 92 and for heating element 92, and the thermocouple 95 which is a temperature sensing element, and the heat transfer object 98. A thermal break 94 is formed in the shape of a rectangular parallelepiped using the asbestos board which is a heat insulator, and the electric heating element 92 is arranged in the one field. The electric heating element 92 has the electric resistance value R, uses nickel chrome alloy heating wire with a rectangle-like cross section, and is area S9. It was formed in plate-like [which it has], and has the lead wire 93 and 93 for current supply sources, and the heat flow rate given to the measuring object object 99 for thermal conductimetry is generated.
[0004] The dimension of the electric heating element 92 in every direction is smaller than field 91of field [in which the electric heating element 92 of a thermal break 94 is arranged], therefore measurement implement 91 a. Chromel Alumel is used for the thermocouple 95, and as the temperature detecting element can touch, it is arranged in the measuring object object 99 by the central part of the electric heating element 92, and it has the lead wire 96 and 97 for an output. The heat transfer object 98 is formed in the shape of a rectangular parallelepiped using the alumina which is thermally conductive material, and field 98b of the opposite side to flat-surface 98a of the shape of a rectangle which touches the measuring object object 99 is equipped with the equipment for cooling illustrated [water cooling type / neither / an air-quenching type nor].
[0005] Flat-surface 99b of another side of the direction of thickness d is stuck to the measuring object

object 99 which is a plate-like member by flat-surface 98a of the heat transfer object 98, and field 91a in which the electric heating element 92 of the measurement implement 91 is arranged in one flat-surface 99a of the direction of thickness d is loaded with it at thermal conductivity measuring apparatus 9. This measuring object object 99 has a rectangle-like field configuration, that dimension in every direction is larger than field 91a of the measurement implement 91, and it is set up smaller than flat-surface 98a of the heat transfer object 98. Then, thermal conductivity measuring apparatus 9 is an arrow head F9 about the measurement implement 91, in order to stick certainly the flat surfaces 99a and 99b of the measuring object object 99 to field 91a of the measurement implement 91, and flat-surface 98a of the heat transfer object 98. It has equipment for pressurization which is pressurized from a direction and which is not illustrated.

[0006] It is constituted as mentioned above and the thermal conductivity measuring apparatus 9 for the plate-like members of the conventional example is thermal conductivity lambdaX of the measuring object object 99. It carries out like degree account and asks. First, constant current I is energized to the electric heating element 92 by each in the condition that thermal conductivity measuring apparatus 9 was loaded with the measuring object object 99, and the condition of not being loaded. The temperature rise values t91 and t92 are measured noting that it is the temperature rise value of the part where flat-surface 99a of the measuring object object 99 touches the electric heating element 92 in the output of a thermocouple 95, when the temperature of each part -- the output of a thermocouple 95 is saturated -- will be in a fixed condition. Thermal conductivity lambdaX of the measuring object object 99 with thickness d It has obtained based on the formula (1) using the constant current I energized to these temperature rise values t91 and t92, area S9 of the electric heating element 92 and the electric resistance value R, and the electric heating element 92.

[0007]

[Equation 1]

$$\text{lambda}X = 2I2\ Rd/\{(2t91-t92)\ S9\} \quad \ldots\ldots\ldots\ldots\ (1)$$

[0008]

[Problem(s) to be Solved by the Invention] Thereby, as for the thermal conductivity measuring apparatus 9 for plate-like members by the conventional technique mentioned above, a proper thermal conductivity value can be calculated from the measuring object object 99 with a thermal conductivity value uniform in the direction of a field excluding fillers, such as polyester film, etc. However, the ingredient which uses a filler etc. like FRP material (for example, epoxy glass laminate) out of the ingredient which does not contain fillers, such as polyester film, etc. in the plate-like electric insulator used for the electric insulation of an electric machine is also used abundantly. The trouble in the case of asking for the thermal conductivity of such an ingredient by thermal conductivity measuring apparatus 9 is represented when the measuring object object 99 is FRP material, and it explains.

[0009] When the measuring object object 99 is FRP material, the heat-conductivity value of the measuring object object 99 is not uniform by existence of a fiber (the case of an epoxy glass laminate glass fiber) about the direction of a field. Then, the local heat-conductivity value of the direction of a field of the measuring object object 99 has resin material larger than the part existing [many] by the part by which many fibers exist as known well. When searching for such a measuring object object 99 by thermal conductivity measuring apparatus 9, the output values of a thermocouple 95 differ by whether the part in contact with the measuring object object 99 of the temperature detecting element of a thermocouple 95 is a part where many fibers exist, or it is the part where many resin material exists. That is, at thermal conductivity measuring apparatus 9, the thermal conductivity value of the plate-like member for which the filler etc. was used was not able to be calculated with high degree of accuracy.

[0010] This invention is made in view of the trouble of the above-mentioned conventional technique, and that purpose is in offering the thermal conductivity measuring apparatus which can calculate the thermal conductivity value of the plate-like member for which the filler etc. was used with high degree of accuracy.

[0011]

[Means for Solving the Problem] The heating element section in which the above-mentioned purpose

has a heat transfer object for the heating element sections made from 1 electrical-and-electric-equipment heating element and the thermally conductive material by which the temperature detecting element for heating element section sides was arranged in the plane end-face side while giving the heat with which it has a plane end face and was generated with the electric heating element to the measuring object object from said plane end face in this invention, While receiving the heat generated with the radiator and said electric heating element by the plane end face which has the almost same field configuration and dimension as the plane end face of the heat transfer object for the heating element sections through a measuring object object and transporting to said radiator The radiator section which has a heat transfer object with the temperature detecting element for the radiator section sides which were made to counter mostly the temperature detecting element for heating element section sides, and were arranged in the plane end-face side for the radiator sections made from thermally conductive material, It has the thermal break arranged around the heat transfer object for the radiator sections, a measuring object object, and the heating element section. said measuring object object with the field configuration and the dimension almost same plate-like as the plane end face of the heat transfer object for the heating element sections being inserted between each plane end face of the heating element section and the radiator section, and being stuck to each of the flat surface of the both sides of this measuring object object by said plane end face of the heating element section and the radiator section -- or 2) In a means given in said 1st term, said heating element section and/or said radiator section have an attachment object for the temperature detecting elements for attaching the temperature detecting element for heating element section sides, and the temperature detecting element for radiator section sides in a measuring object object side. This attachment object has the field configuration and the dimension almost same at the product made from thermally conductive material as the plane end face by the side of the measuring object object of the heat transfer object for the heating element sections, Or in the means of a publication, the exoergic section is distributed over the range of a field configuration and a dimension with said electric heating element almost equivalent to the plane end face of the heat transfer object for the heating element sections, and it is arranged by 3 aforementioned 1 term or the 2nd term. Said heat transfer object for the heating element sections to being formed in the plane in which the end face which an electric heating element touches has the almost same field configuration and dimension as said plane end face by the side of a measuring object object, and a pan Or it sets for a means given in either from 4 aforementioned 1 term to the 3rd term. Between said heating element sections and measuring object objects or between a measuring object object and said radiator section It has the known sample member by which the middle attachment object and thermal conductivity for temperature detecting elements by which the temperature detecting element was arranged in the part which counters mostly the temperature detecting element for the heating element sections were produced with the known ingredient. A known sample member is formed in plate-like [of the almost same field configuration and dimension as a measuring object object], and a middle attachment object is attained by being arranged in contact with a measuring object object while being formed in plate-like [with the almost same field configuration and dimension as the plane end face by the side of the measuring object object of said heat transfer object for the heating element sections].

[0012]

[Embodiment of the Invention] The gestalt of implementation of this invention is explained to a detail with reference to a drawing below. Drawing 3 is the side elevation showing the thermal conductivity measuring apparatus for plate-like members with an example of the gestalt of implementation of this invention with a measuring object object fractured in part, drawing 4 is the sectional view of the Q section in drawing 3 of the heat transfer object for the heating element sections shown in drawing 3 , drawing 5 is drawing showing the important section of the radiator shown in drawing 3 , (a) is a plan and (b) is the side elevation of drawing 5 (a). In drawing 3 - drawing 5 , 2 is the thermal conductivity measuring apparatus for plate-like members by this invention equipped with heating element section 3A, radiator section 4A, the thermal break 6, and the pressure plate 7, and 19 is a measuring object object and is inserted between heating element section 3A and radiator section 4A. This measuring object object 19 is the plate-like member of thickness d like the measuring object object 99 explained by the

term of a "Prior art", and FRP material etc. is contained in the ingredient used.
[0013] Heating element section 3A has the electric heating element 31 and the heat transfer object 33 for the heating element sections, and the electric heating element 31 generates the heat flow rate given to the measuring object object 19 like the electric heating element 92 of the conventional example for thermal conductimetry. Moreover, even if the heat transfer object 33 does not have the uniform area consistency of the heat which FRP material with a thermal conductivity value uneven in the direction of a field etc. is applied to the measuring object object 19, and is moreover generated with the electric heating element 31, the heat generated with the electric heating element 31 is bearing the duty which equates mostly the consistency of the heat flow rate in the part which passes 33d of lower end faces. For this reason, it is formed in the shape of a rectangular parallelepiped using the copper material which is a material which has thermal conductivity with the good heat transfer object 33 in the case of this example. that thickness H3 it is the need in order to achieve said duty of the heat transfer object 33 -- enough -- alike -- a long dimension -- [-- in the case of this example, it is set up by H3 **0.4(S3) 1/2] when area of 33d of lower end faces is set to S3.
[0014] With this heat transfer object 33, up end-face 33u and 33d of lower end faces have the same configuration and dimension, they are formed in a plane, and that of its field configuration and dimension are the same as that of the field configuration and dimension of the measuring object object 19. Closed-end hole 33a of a minor diameter makes it connect with the center section of 33d of the lower end faces of the heat transfer object 33 at this closed-end hole 33a, and closed-end hole 33c of a minor diameter is formed from the side face of the heat transfer object 33, respectively. These closed-end holes 33a and 33c are loaded with thermocouple 8A which is a temperature sensing element for heating element section sides as shown in drawing 4 . The heat-resistant thermocouple with which fluororesin material was used is adopted as the pre-insulation material for strands, and a jacket insulating material by both thermocouple 8A, the edge of both strands is electrically connected by well-known proper technique, and a temperature detecting element is formed. It is fixed to the heat transfer object 33 with a filler 331, sequential insertion being carried out at closed-end hole 33c and closed-end hole 33a, and this thermocouple 8A being used as the condition of having made the temperature detecting element projecting a little from 33d of lower end faces.
[0015] Then, the temperature detecting element of thermocouple 8A fixed to closed-end hole 33a of the heat transfer object 33 has a point processed so that it may become the same field as 33d of lower end faces (see drawing 4). The flexible electric heater formed in the plate-like appearance which has the appearance of the same field configuration and dimension as up end-face 33u by covering with silicone rubber material the exoergic section which heating wire was made for the electric heating element 31 to move in a zigzag direction, and was arranged in the shape of a field is used. This electric heating element 31 is laid in up end-face 33u of the heat transfer object 33. Therefore, the uniformity coefficient of the consistency of the heat flow rate obtained by up end-face 33u improves with the heat generated in the exoergic section of the electric heating element 31 as contrasted with the case where the electric heating element 92 of the conventional example is used. In addition, this electric heating element 31 has equipped one with the temperature sensor which is not illustrated for detecting the temperature of the electric heating element 31.
[0016] Radiator section 4A has the heat transfer object 42 and radiator 43 for the radiator sections. This heat transfer object 42 Even if the area consistency of the heat which FRP material with a thermal conductivity value uneven in the direction of a field etc. is applied to the measuring object object 19, and is moreover removed with a radiator 43 is not uniform The heat transmitted to the heat transfer object 42 from the measuring object object 19 is bearing the duty which makes almost equal the consistency of the heat flow rate in the part which passes up end-face 42u. For this reason, in the case of this example, the heat transfer object 42 is formed in the shape of a rectangular parallelepiped using the copper material which is a material which has good thermal conductivity like the heat transfer object 33, and it is that thickness H4. In order to achieve said duty of the heat transfer object 42, it is set as the sufficiently long dimension which is the need.
[0017] Then, in the case of this example, the heat transfer object 42 for the radiator sections has

completely same the structure, configuration, and the dimension as the heat transfer object 33 for the heating element sections, and the difference with the heat transfer object 33 is only reversing the upper and lower sides and using. Therefore, thickness H4 of the heat transfer object 42 Thickness H3 of the heat transfer object 33 It is the same, and up end-face 42u and 42d of lower end faces have the same configuration and dimension as 33d of lower end faces of the heat transfer object 33, and the closed-end hole for loading with the temperature detecting element of thermocouple 8D which is a temperature sensing element for radiator section sides is formed in up end-face 42u. Since the contents of thermocouple 8D, the formation location of a closed-end hole, the loading approach to the heat transfer object 42, etc. are completely the same as that of the case of thermocouple 8A, duplication is avoided and the explanation is omitted.

[0018] A radiator 43 is the radiator of the water cooling type cooled using cooling water 49, and as shown in drawing 5 , it is equipped with the rectangular parallelepiped-like body 44 of a radiator, and two or more piping members 45-48 by the product made from copper material. Three through tubes 441 which are mutually parallel to the body 44 of a radiator are formed like illustration, it connects with this through tube 441 watertight, and the piping members 45-48 form one flowing path for cooling water 49 which continues as a whole. In addition, the piping member 45 is a member for inlet ports into which cooling water 49 is made to flow, and the piping member 48 is a member for outlets which makes cooling water 49 discharge. The heat transfer object 42 is attaching a radiator 43 in contact with 42d of lower end faces, and can hold the temperature of 42d of lower end faces at low temperature.

[0019] In addition, although end-face 43u of the radiator 43 which touches 42d of lower end faces and 42d of lower end faces of the heat transfer object 42 is both made into the smooth field, in order to reduce the contact thermal resistance between both, it is desirable to insert spreading of grease etc., the foil made from an elasticity metal (for example, indium), etc. in both joint. In addition, also between 33d of lower end faces of the measuring object object 19 and the heat transfer object 33, and up end-face 42u of the heat transfer object 42, or between up end-face 33u of the electric heating element 31 and the heat transfer object 33, in order to reduce the contact thermal resistance between each, grease etc. can be applied again if needed.

[0020] A thermal break 6 consists of a wrap heat-insulating element 61 and a heat-insulating element 62 arranged in the perimeter of heating element section 3A, the measuring object object 19, and the heat transfer object 42 in the upper part of the electric heating element 31 of heating element section 3A. In the case of this example, while heat insulation property is excellent, ceramic fiber [fine FREX 1300 paper by NICHIAS CORP.] etc. is used as a heat insulator with good workability at heat-insulating elements 61 and 62. It is checked by examination of the artificers about thermal conductivity measuring apparatus 2 that heat insulation property of the thermal break 6 using fine FREX 1300 paper improves exceeding 150 [%] as contrasted with the case where the same asbestos board as the conventional example is used.

[0021] A pressure plate 7 is formed in the shape of a rectangular parallelepiped using iron material, and is arranged in the top face of a heat-insulating element 61. In order to make the four-corners section of the top face of a pressure plate 7 stick certainly both the flat surfaces (equivalent to the flat surfaces 99a and 99b by the conventional example) of the measuring object object 19 to each of up end-face 42u of 33d of lower end faces of the heat transfer object 33 for the heating element sections, and the heat transfer object 42 for the radiator sections It is an arrow head F2 about a pressure plate 7. It is equipped with the equipment for pressurization which consisted of coiled spring which pressurizes a direction and which is not illustrated. The welding pressure given to a pressure plate 7 takes into consideration the pressure value received when the measuring object object 19 is used with the system, and is set up. Then, impression of this welding pressure is effective also in reduction of the contact thermal resistance of above mentioned each part.

[0022] Since it considered as the above-mentioned configuration in the thermal conductivity measuring apparatus 2 for plate-like members with an example of the gestalt of implementation of this invention shown in drawing 3 - drawing 5 , after carrying out conduction of the part of many of the heat generated with the electric heating element 31 in the path of electric heating element 31 -> heat transfer object 33 -

> lower end-face 33d-> measuring object object 19 -> up end-face 42u-> heat transfer object 42 -> radiator 43 -> cooling water 49, it is emitted to cooling water 49. Moreover, a part of heat generated with the electric heating element 31 is emitted to perimeter space from the lateral portion of the top-face section of the electric heating element 31, a lateral portion and the heat transfer object 33, the measuring object object 19, and the heat transfer object 42 etc.

[0023] However, although the amount of this heat emitted to perimeter space by arranging the thermal break 6 will be controlled and stripping of the little heat will be carried out to perimeter space in thermal conductivity measuring apparatus 2, in order to supply this stripping heat, the heat flow rate for stripping heat exists in thermal conductivity measuring apparatus 2. The part as for which the heat flow rate for these stripping heat carries out conduction is substantially limited near the lateral portion of the heat transfer object 33, the measuring object object 19, and the heat transfer object 42 by thermal conductivity measuring apparatus 2. Therefore, in a part for the core of 33d of lower end faces in which closed-end hole 33a is formed, and up end-face 42u (the temperature detecting element of thermocouple 8A and thermocouple 8D is attached), it is not influenced by the heat flow rate for stripping heat.

[0024] Then, thermal conductivity measuring apparatus 2 is equipped with the heat transfer object 33 and the heat transfer object 42 with said configuration made from copper material (material with good thermal conductivity). By this, the heat transfer object 33 equates the consistency of the heat flow rate in the part which passes 33d of lower end faces, and the heat transfer object 42 equates the consistency of the heat flow rate in the part which passes up end-face 42u. The heat flow rate which is generated with the electric heating element 31 in thermal conductivity measuring apparatus 2 from things, such as this, and is given to the measuring object object 19 as an object for measurement of thermal conductivity serves as a uniform consistency substantially in the neighborhood in which the temperature detecting element of thermocouple 8A of 33d of lower end faces and up end-face 42u and thermocouple 8D is attached. By this, even if the measuring object object 19 is a measuring object object with local thermal conductivity values uneven in the direction of a field, such as FRP material, in thermal conductivity measuring apparatus 2, the area consistency of the heat flow rate given to the measuring object object 19 becomes homogeneity in the neighborhood in which thermocouple 8A and thermocouple 8D are attached at least.

[0025] therefore, the temperature detecting element of thermocouple 8A and thermocouple 8D -- each mean temperature of both the flat surfaces (equivalent to the flat surfaces 99a and 99b by the conventional example) of the measuring object object 19 -- tA and tD ****** -- it is detectable. Moreover, since the temperature detecting element of thermocouple 8A and thermocouple 8D is formed so that the point may become the same field as 33d of lower end faces, and up end-face 42u (see drawing 4), even if the loading location to the thermal conductivity measuring apparatus 2 of the measuring object object 19 shifts in the direction of a field, it does not receive effect in detection of the temperature of both the flat surfaces of the measuring object object 19.

[0026] Then, at thermal conductivity measuring apparatus 2, it is thermal conductivity lambdaX of the measuring object object 19. It carries out like degree account and asks. First, grease etc. applies and inserts the measuring object object 19 in both sides if needed between 33d of lower end faces of the heat transfer object 33 for the heating element sections, and up end-face 42u of the heat transfer object 42 for the radiator sections, and after carrying out conduction of the cooling water 49 to a radiator 43, it energizes to the electric heating element 31. They are the temperature value tA and tD noting that it is the temperature value of both sides of the measuring object object 19 about the output of Thermocouples 8A and 8D, when the temperature of each part -- the output of Thermocouples 8A and 8D is saturated -- will be in a fixed condition. It measures. Thermal conductivity lambdaX of the plate-like measuring object object 19 with thickness d This temperature value tA and tD It is obtained by the formula (2) based on the power P given to the area S and the electric heating element 31 of the measuring object object 19.

[0027]

[Equation 2]

$$\lambda X = \beta P.d/\{S-(tA-tD)\} \quad \ldots\ldots\ldots\ldots (2)$$

However, beta is a correction factor about the heat release from the thermal break 6 of the thermal conductivity measuring apparatus 2 to the power P given to the electric heating element 31.
[0028] This correction factor beta is obtained from a thermal break 6 by calculating the heating value by which stripping is carried out by proper approaches, such as count. That is, thermal conductivity measuring apparatus 2 can calculate the thermal conductivity value with high degree of accuracy, even if the plate-like measuring object object 19 uses fillers, such as FRP material, etc.
[0029] By the way, at the thermal conductivity measuring apparatus for plate-like members by this invention, the heat transfer object for the heating element sections and the heat transfer object for the radiator sections do not necessarily need to make it MASSHIBU structure using the material which has good thermal conductivity like the heat transfer object 33 and the heat transfer object 42. Namely, the heat transfer object for the heating element sections and the heat transfer object for the radiator sections It is formed so that it may have the plane end face in which the part which touches both sides of the measuring object object 19 using a material with good thermal conductivity has the almost same field configuration and dimension as the measuring object object 19. A temperature detecting element is arranged in this plane end face. For example, if the area consistency of the heat flow rate which is generated with an electric heating element (there is not necessarily no need of being formed in the plate-like appearance which has the same field configuration and dimension as the measuring object object 19 like the electric heating element 31), and is given to the measuring object object 19 is substantially made into homogeneity by the part adjacent to the field of the measuring object object 19 The heat transfer object for the heating element sections and the heat transfer object for the radiator sections are easy to have proper structure.
[0030] That is, the heat transfer object for the heating element sections and/or the heat transfer object for the radiator sections enclose a refrigerant with a low-boiling point, and you may make it transmit a heat flow rate using boiling heat transfer and the heat transfer of condensation. however, if the heat transfer object 33 for the heating element sections and the heat transfer object 42 for the radiator sections are contrasted with the thing using said boiling heat transfer and heat transfer of condensation which were carried out, it can be said that it is comparatively alike and a simple configuration can attain the purpose because complicated processing of vacuum suction processing, vacuum **** end processing, etc. is unnecessary.
[0031] Next, the thermal conductivity measuring apparatus for plate-like members by the example from which the gestalt of implementation of this invention differs using drawing 6 and drawing 7 is explained. Drawing 6 is the side elevation showing the thermal conductivity measuring apparatus for plate-like members by the example from which the gestalt of implementation of this invention differs with a measuring object object and a known sample member fractured in part here, and drawing 7 is the side-face sectional view showing the important section of the middle attachment object for temperature detecting elements shown in drawing 6 . In addition, in the following explanation, the same sign is given to the same part as the thermal conductivity measuring apparatus of this invention and the measuring object object which were shown in drawing 3 - drawing 5 , and that explanation is omitted. Moreover, he is trying to describe only a typical sign as much as possible all over drawing used for future explanation about the sign attached by drawing 3 - drawing 5 .
[0032] In drawing 6 and drawing 7 , 2A is the thermal conductivity measuring apparatus for plate-like members which adds the middle attachment object 5 for temperature detecting elements, and it had to the thermal conductivity measuring apparatus 2 by this invention shown in drawing 3 - drawing 5 , and 18 is a known sample member. The known sample member 18 is that thermal conductivity lambdaS. It is a known plate-like member, and while having the same field configuration and dimension as the measuring object object 19, in the case of this example, that thickness also has the same thickness d as the measuring object object 19. The middle attachment object 5 is formed in the shape of a rectangular parallelepiped using the copper material which is a material with good thermal conductivity, the up end-face 5u and 5d of lower end faces have the same configuration and dimension, they are formed in a plane, and its field configuration and dimension of it are the same as the field configuration and dimension of the measuring object object 19.

[0033] Closed-end hole 5b of a minor diameter makes it connect [a / of a minor diameter / closed-end hole 5] with both these closed-end holes 5a and 5b in the center section of 5d of the lower end faces in the center section of up end-face 5u of the middle attachment object 5, and closed-end hole 5c of a minor diameter is formed from the side face of the middle attachment object 5, respectively. In addition, the formation locations of both the closed-end holes 5a and 5b are closed-end hole 33a currently formed in the heat transfer object 33, and a part which counters. These closed-end holes 5a and 5c are loaded as thermocouple 8C whose thermocouple 8B which is a temperature sensing element is a temperature sensing element again at the closed-end holes 5b and 5c shows drawing 7 . In addition, since the contents of the thermocouples 8B and 8C, the formation location of a closed-end hole, the loading approach to the middle attachment object 5, etc. are the same as that of the case of thermocouple 8A, duplication is avoided and the explanation is omitted.
[0034] Then, the middle attachment object 5 and the known sample member 18 The field where up end-face 5u of the middle attachment object 5 touches the heat transfer object 33 for the heating element sections of the measuring object object 19 is touched in the field of the opposite side. It is arranged in thermal conductivity measuring apparatus 2A, as 5d of lower end faces of the middle attachment object 5 touches one field of the known sample member 18 and the field of another side of the known sample member 18 touches up end-face 42u of the heat transfer object 42 for the radiator sections. In addition, between up end-face 5u of the middle attachment object 5, and the measuring object object 19, in order to reduce contact thermal resistance, grease etc. can be applied to each between 5d of lower end faces of the middle attachment object 5, and the known sample member 18, or between the known sample member 18 and up end-face 42u of the heat transfer object 42 if needed.
[0035] Since it considered as the above-mentioned configuration in thermal conductivity measuring apparatus 2A for plate-like members by the example from which the gestalt of implementation of this invention shown in drawing 6 and drawing 7 differs, the part of many of the heat generated with the electric heating element 31 After carrying out conduction in the path of electric heating element 31 -> heat transfer object 33 -> lower end-face 33d-> measuring object object 19 -> up end-face 5u-> middle attachment object 5 -> lower end-face 5d-> known sample member 18 -> up end-face 42u-> heat transfer object 42 -> radiator 43 -> cooling water 49, it is emitted to cooling water 49. Then, in thermal conductivity measuring apparatus 2A, the area consistency of the heat flow rate which carries out conduction of the known sample member 18 to the measuring object object 19 by the same reason as the case of the above-mentioned thermal conductivity measuring apparatus 2 serves as the same value by the measuring object object 19 and the known sample member 18 while becoming homogeneity in the neighborhood in which thermocouple 8A, thermocouple 8B, thermocouple 8C, and thermocouple 8D are attached at least.
[0036] Then, at thermal conductivity measuring apparatus 2A, it is thermal conductivity lambdaX of the measuring object object 19. It carries out like degree account and asks. The measuring object object 19 first the measuring object object 19 and the known sample member 18 between 33d of lower end faces of the heat transfer object 33, and up end-face 5u of the middle attachment object 5 Moreover, the known sample member 18 applies and inserts grease etc. in both sides if needed, respectively between 5d of lower end faces of the middle attachment object 5, and up end-face 42u of the heat transfer object 42, and after carrying out conduction of the cooling water 49 to a radiator 43, it energizes it to the electric heating element 31.
[0037] They are the temperature values tA, such as it, tB, and tC noting that it supposes that it is the output of Thermocouples 8A and 8B the temperature value of both sides of the measuring object object 19 and is the temperature value of both sides of the known sample member 18 about the output of Thermocouples 8C and 8D, when the temperature of each part -- the output of Thermocouples 8A-8D is saturated -- will be in a fixed condition. And tD It measures. Thermal conductivity lambdaX of the plate-like measuring object object 19 Temperature value tA -tD(s), such as this since the thickness of the measuring object object 19 and the known sample member 18 is the same Thermal conductivity lambdaS of the known sample member 18 It uses and is obtained by the formula (3).
[0038]

[Equation 3]
lambdaX =lambdaS/(tC-tD) (tA-tB) ..... (3)
That is, thermal conductivity measuring apparatus 2A is thermal conductivity lambdaS, even if the plate-like measuring object object 19 uses fillers, such as FRP material, etc. It is being able to use the known plate-like known sample member 18, and the new advantage in which said correction factor beta can be made unnecessary is acquired, holding the advantage which the above-mentioned thermal conductivity measuring apparatus 2 has as it is. Then, if thermal conductivity measuring apparatus 2A is contrasted with thermal conductivity measuring apparatus 2, while parameters are reducible from the case of thermal conductivity measuring apparatus 2, the accuracy of measurement can be improved further.
[0039] The thermal conductivity measuring apparatus for plate-like members by the example from which drawing 1 and drawing 2 are used and the gestalt of implementation of this invention finally differs further is explained. Drawing 1 is the side elevation showing the thermal conductivity measuring apparatus for plate-like members by the example from which the gestalt of implementation of this invention differs further with a measuring object object and a known sample member fractured in part here, and drawing 2 is the side-face sectional view showing the important section of the attachment object for the temperature detecting elements of the heating element section shown in drawing 1 . In addition, in the following explanation, the same sign is given to the same part as the thermal conductivity measuring apparatus of this invention and the known sample member which were shown in drawing 6 and drawing 7 , and that explanation is omitted. Moreover, he is trying to describe only a typical sign as much as possible all over drawing used for future explanation about the sign attached by drawing 6 and drawing 7 .
[0040] In drawing 1 and drawing 2 , 1 is the thermal conductivity measuring apparatus for plate-like members which changes to heating element section 3A and radiator section 4A, and used the heating element section 3 and the radiator section 4 to thermal conductivity measuring apparatus 2A by this invention shown in drawing 6 and drawing 7 , respectively. When the heating element section 3 is contrasted with heating element section 3A, in the heating element section 3, changing to the heat transfer object 33 for the heating element sections which heating element section 3A has, and using the heat transfer object 32 for the heating element sections and the attachment object 39 for temperature detecting elements only differ. Since the heat transfer object's 32 being said to be what removed the loading section of thermocouple 8A, such as the closed-end holes 33a and 33c, from the heat transfer object 33, and being formed in the shape of a rectangular parallelepiped using copper material, and a field configuration and a dimension are the same as that of the heat transfer object 33, duplication is avoided and the explanation is omitted.
[0041] The attachment object 39 is formed in the shape of a rectangular parallelepiped using the copper material which is a material with good thermal conductivity, the up end-face 39u and 39d of lower end faces have the same configuration and dimension, they are formed in a plane, and its field configuration and dimension of it are the same as the field configuration and dimension of the measuring object object 19. Closed-end hole 39a of a minor diameter makes it connect with the center section of 39d of the lower end faces of the attachment object 39 at this closed-end hole 39a, and closed-end hole 39c of a minor diameter is formed from the side face of the attachment object 39, respectively. In addition, the formation location of closed-end hole 39a is the completely same part as the case of closed-end hole 33a formed in said heat transfer object 33.
[0042] These closed-end holes 39a and 39c are loaded as thermocouple 8A shows drawing 2 . In addition, since the loading approach to the attachment object 39 of Thermocouple A is completely the same as that of the case of the heat transfer object 33, duplication is avoided and the explanation is omitted. Moreover, it becomes, it is similar, and the structure of the attachment object 39 is only that only closed-end hole 39a is formed in one end face as a closed-end hole formed in an end face, in order that the difference may load with a thermocouple, the structure of said middle attachment object 5, and. For this reason, the middle attachment object 5 can also be used as an attachment object 39.
[0043] Moreover, when the radiator section 4 is contrasted with said radiator section 4A, in the radiator section 4, changing to the heat transfer object 42 for the radiator sections which radiator section 4A has,

and using the heat transfer object 41 for the radiator sections and the attachment object 49 for temperature detecting elements only differ. Although this heat transfer object 41 can be said to be what removed the loading section of thermocouple 8D, such as a closed-end hole, from said heat transfer object 42, in the case of this example, the heat transfer object 41 has completely same the structure, configuration, and the dimension as the heat transfer object 32 for the heating element sections. Then, the attachment object 49 has completely same the structure, configuration, and the dimension as the attachment object 39, and the differences with the attachment object 39 are only reversing the upper and lower sides and using and that the thermocouple with which it is loaded is thermocouple 8D.

[0044] Then, up end-face 39u of the attachment object 39 touches the lower end face of the heat transfer object 32 for the heating element sections, and 39d of lower end faces of the attachment object 39 touches the top face of the measuring object object 19, and the up end face of the attachment object 49 touches the inferior surface of tongue of the known sample member 18, and the attachment objects 39 and 49 are arranged in thermal conductivity measuring apparatus 1 as the lower end face of the attachment object 49 touches the up end face of the heat transfer object 41. In addition, although each up end face of the heat transfer object 41 is made into the smooth field at the upper part of up end-face 39of lower end-face [of the heat transfer object 32], and attachment object 39 u and 39d of lower end faces, and the attachment object 49 and the lower end face, and the pan In order to reduce the contact thermal resistance between the lower end face of the heat transfer object 32, and up end-face 39u of the attachment object 39, and between the lower end face of the attachment object 49, and the up end face of the heat transfer object 41 It is desirable to insert spreading of grease etc., the foil made from an elasticity metal (for example, indium), etc. in joints, such as this.

[0045] Since it considered as the above-mentioned configuration in the thermal conductivity measuring apparatus 1 for plate-like members by the example from which the gestalt of implementation of this invention shown in drawing 1 and drawing 2 differs further, the part of many of the heat generated with the electric heating element 31 Electric heating element 31 -> heat transfer object 32 -> attachment object 39 -> lower end-face 39d-> measuring object object 19 -> middle attachment object 5 -> known sample member 18 -> up end face (end face it is the same as that of 39d) -> after carrying out conduction in the path of attachment object 49 -> heat transfer object 41 -> radiator 43 -> cooling water 49, it is emitted to cooling water 49. Since it is fundamentally the same, the path of the heat flow rate in this thermal conductivity measuring apparatus 1 is [the case of the above-mentioned thermal conductivity measuring apparatus 2A, and] thermal conductivity lambdaX of the plate-like measuring object object 19 in the case of thermal conductivity measuring apparatus 1. Since it can obtain using said formula (3) like the case of thermal conductivity measuring apparatus 2A, duplication is avoided and that explanation is omitted.

[0046] Then, while thermal conductivity measuring apparatus 1 holds the advantage which the above-mentioned thermal conductivity measuring apparatus 2A has as it is, it is using the wearing place of Thermocouples 8A and 8D as the attachment objects 39 and 49 thinner [than this etc.] and lightweight from the heat transfer object 33 in thermal conductivity measuring apparatus 2A, and the heat transfer object 42, and wearing to said closed-end hole of Thermocouples 8A and 8D becomes easy. That is, thermal conductivity measuring apparatus 1 can reduce the manufacturing cost about wearing of Thermocouples 8A and 8D as compared with the case of thermal conductivity measuring apparatus 2 and 2A.

[0047] In the above-mentioned explanation, although the known sample member 18 came noting that it was arranged in the downstream of the measuring object object 19 about the heat flow rate generated with the electric heating element 31, it is not limited to this and may be arranged in the upstream of the measuring object object 19. Moreover, it came by the above-mentioned explanation noting that the thickness of the known sample member 18 was the same as that of thickness d of the measuring object object 19, but it is not limited to this, and even if the thickness of the known sample member 18 differs from thickness d of the measuring object object 19, there is no inconvenience in any way. However, it is necessary to make a formula (3) correspond to this and to improve it.

[0048]

[Effect of the Invention] In the thermal conductivity measuring apparatus for plate-like members by this invention, it is considering as the configuration stated by the term of said The means for solving a technical problem, and degree effectiveness which carries out an account can be acquired.
** The area consistency of the heat flow rate which carries out conduction of a measuring object object, the temperature detecting element for heating element section sides, and the temperature detecting element for radiator section sides can be made the same by considering as the configuration by the ** (1) term of the term of said The means for solving a technical problem, and the ** (2) term. Moreover, even if the loading location to the thermal conductivity measuring apparatus of a measuring object object shifts in the direction of a field, change is not substantially given to the temperature gradient produced in the thickness direction of a measuring object object. By things, such as this, even if a local thermal conductivity value is a measuring object object uneven in the direction of a field, measurement with the high degree of accuracy of the temperature gradient produced in the thickness direction of a measuring object object is attained, and it becomes possible to measure the thermal conductivity of a plate-like member with high degree of accuracy. Moreover, [0049] ** The simplification of the structure of the heat transfer object for the heating element sections is attained being able to use all the field configuration and dimensions of a measuring object object, a heating element, and the heat transfer object for the heating element sections as almost the same by considering as the configuration by the ** (3) term of the term of said The means for solving a technical problem, and reduction of the manufacturing cost of the thermal conductivity measuring apparatus for plate-like members is attained, holding the effectiveness by the aforementioned ** term. Since the area consistency of the heat flow rate which carries out conduction of each central part of a measuring object object and a known sample member can be made the same further again by considering as the configuration by ** ** (4) term of the term of said The means for solving a technical problem and consideration of the correction factor about the heat release from a thermal break becomes unnecessary, the further improvement in the accuracy of measurement of the thermal conductivity of a plate-like member is attained.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The side elevation showing the thermal conductivity measuring apparatus for plate-like members by the example from which the gestalt of implementation of this invention differs further with a measuring object object and a known sample member fractured in part
[Drawing 2] The side-face sectional view showing the important section of the attachment object for the temperature detecting elements of the heating element section shown in drawing 1
[Drawing 3] The side elevation showing the thermal conductivity measuring apparatus for plate-like members with an example of the gestalt of implementation of this invention with a measuring object object fractured in part
[Drawing 4] The sectional view of the Q section in drawing 3 of the heat transfer object for the heating element sections shown in drawing 3
[Drawing 5] In drawing showing the important section of the radiator shown in drawing 3 , (a) is a plan and (b) is the side elevation of drawing 5 (a).
[Drawing 6] The side elevation showing the thermal conductivity measuring apparatus for plate-like members by the example from which the gestalt of implementation of this invention differs with a measuring object object and a known sample member fractured in part
[Drawing 7] The side-face sectional view showing the important section of the middle attachment object for temperature detecting elements shown in drawing 6
[Drawing 8] Drawing of longitudinal section showing the important section of the thermal conductivity measuring apparatus for the plate-like members of the conventional example with a measuring object object
[Description of Notations]
1 Thermal Conductivity Measuring Apparatus
18 Known Sample Member
19 Measuring Object Object
3 Heating Element Section
31 Electric Heating Element
32 Heat Transfer Object
39 Attachment Object
4 Radiator Section
41 Heat Transfer Object
43 Radiator
49 Attachment Object
5 Middle Attachment Object
6 Thermal Break
61 Heat-insulating Element
62 Heat-insulating Element
7 Pressure Plate

8A Thermocouple
8B Thermocouple
8C Thermocouple
8D Thermocouple

[Translation done.]

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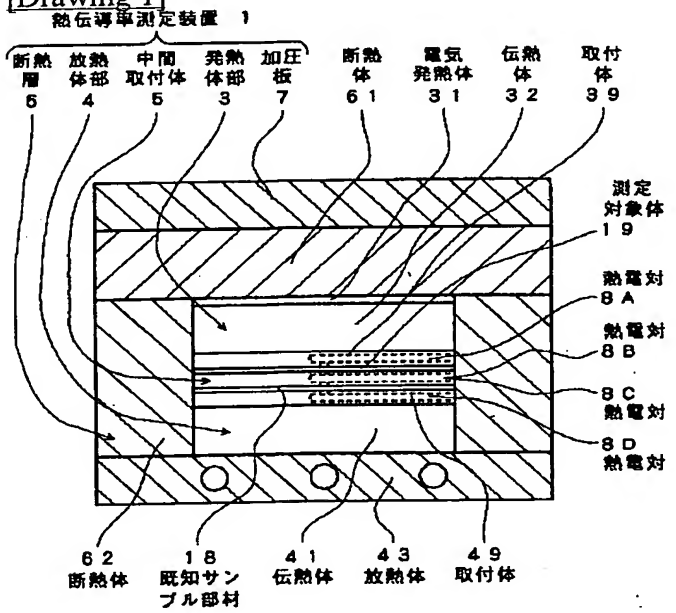
DRAWINGS

[Drawing 1]



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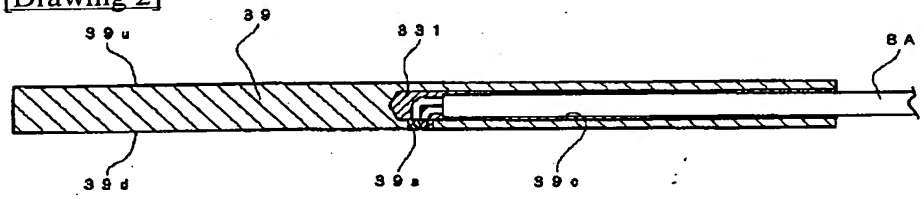

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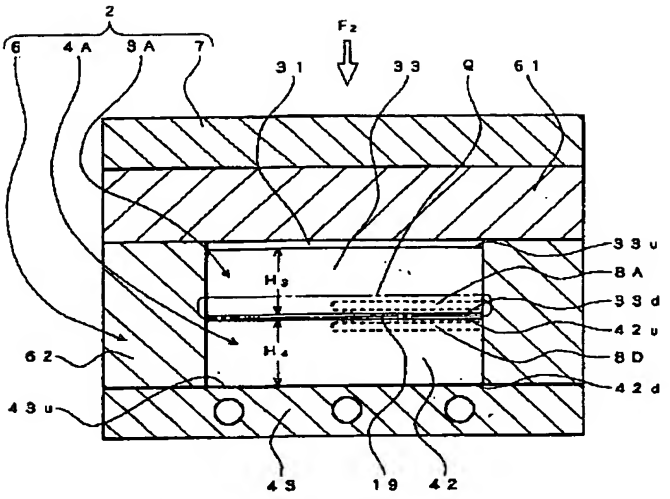

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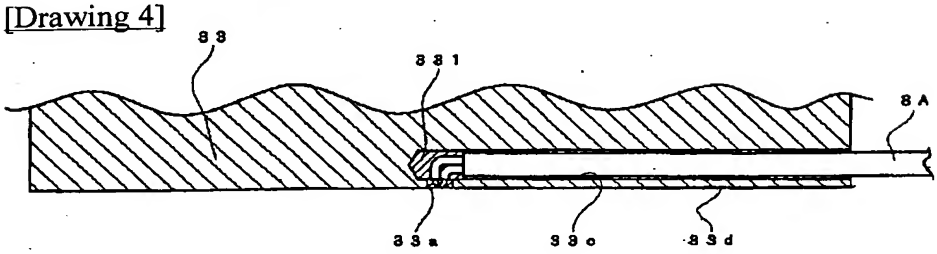

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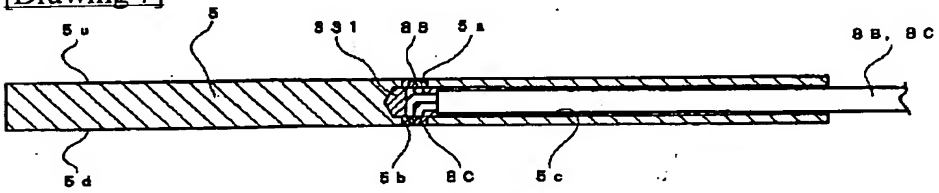

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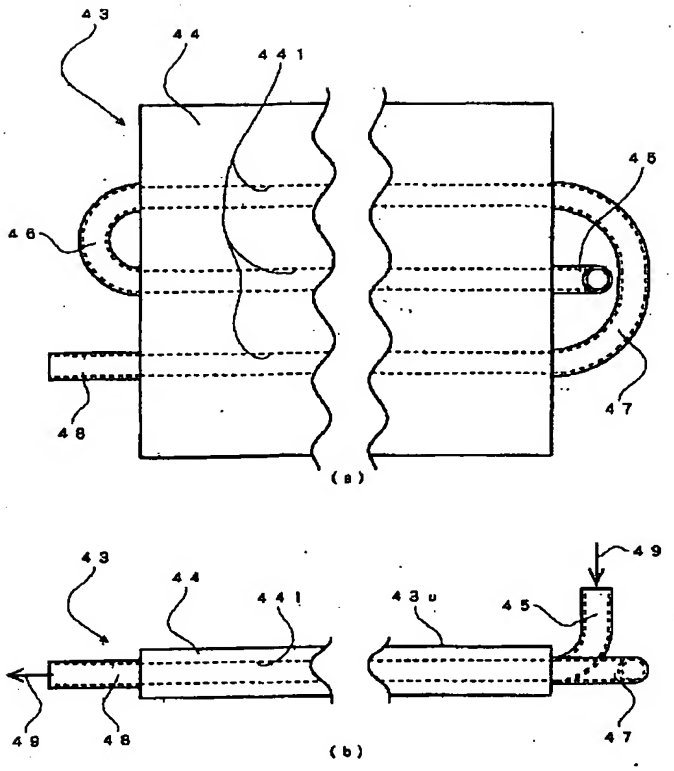
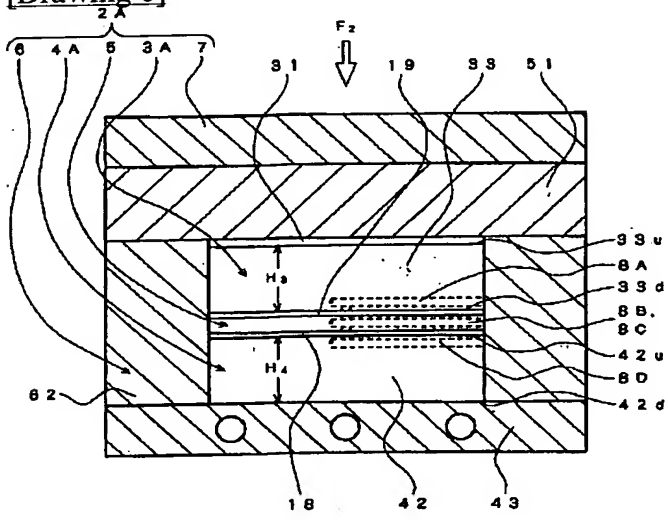
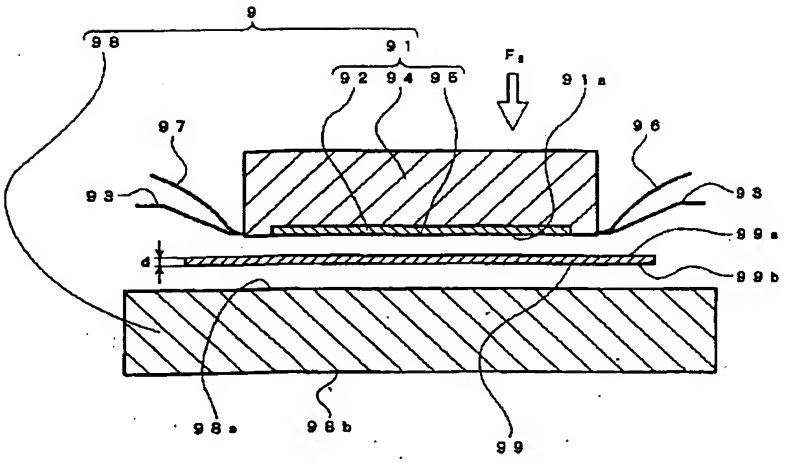


[Drawing 6]



[Drawing 8]



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